CR-152358

BK067-1004

LONG TERM TESTS

OF THE

HEPP LIQUID TRAP DIODE HEAT PIPE PROTOTYPE

FINAL REPORT

April 1980

(NASA-CR-152358) LONG TERM TESTS OF THE HEPP LIQUID TRAP DIODE HEAT PIPE PROTOTYPE Final Report (B & K Engineering, Inc., Towson, Md.) 11 p HC A02/MF A01 CSCL 20D

N80-22635

Unclas

G3/34 19582

Prepared for

NASA Ames Research Center

Under

Contract No. NAS2-10203

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1.0 INTRODUCTION

This report presents the test results which were obtained with the HEPP liquid trap diode heat pipe prototype after it had been in storage for almost 27 months. Original test results were reported in Ref. 1. Transport data was obtained over the range of 150° to 220°K and reverse mode shutdown was measured with nominal operation at 180°K.

2.0 DIODE HEAT PIPE CONFIGURATION

The heat pipe was fabricated from axially grooved stainless steel tubing whose cross-section is shown in Fig. 2-1. Tubing characteristics are summarized in Table 2-1. Ethane is the working fluid and the nominal operating temperature is 180°K. The heat pipe's configuration is shown in Fig. 2-2. The pipe is bent in a symetrical U-shape with a 33.3 cm (13-1/8 in.) centerline to centerline separation. It has a 10.2 cm (4-in.) evaporator, a 45.7 cm (18-in.) condenser and an effective transport length of 1.01 m.

The liquid trap reservoir is fabricated from a 10.2 cm (4-in.) length of 2.54 cm (1.00-in.) O.D. stainless steel tubing. The reservoir's inner wall has circumferential grooves to promote liquid condensation. A slab wick, formed from continuous wraps of 100 mesh stainless steel screen is inserted in the reservoir to contain the condensed liquid. Bridges are attached to this wick to allow for communication with the grooved reservoir wall. The reservoir is directly adjacent and parallel to the evaporator section and communicates with the heat pipe through a 0.46 cm (0.18-in.) I.D. stainless steel U-shaped connecting tube. This diameter is sufficiently large to prevent any capillary

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1. BK034-1004, "Development of a Stainless Steel Axially Grooved Low Temperature Liquid Trap Diode Heat Pipe Prototype," B & K Engineering, Inc., January 1978.

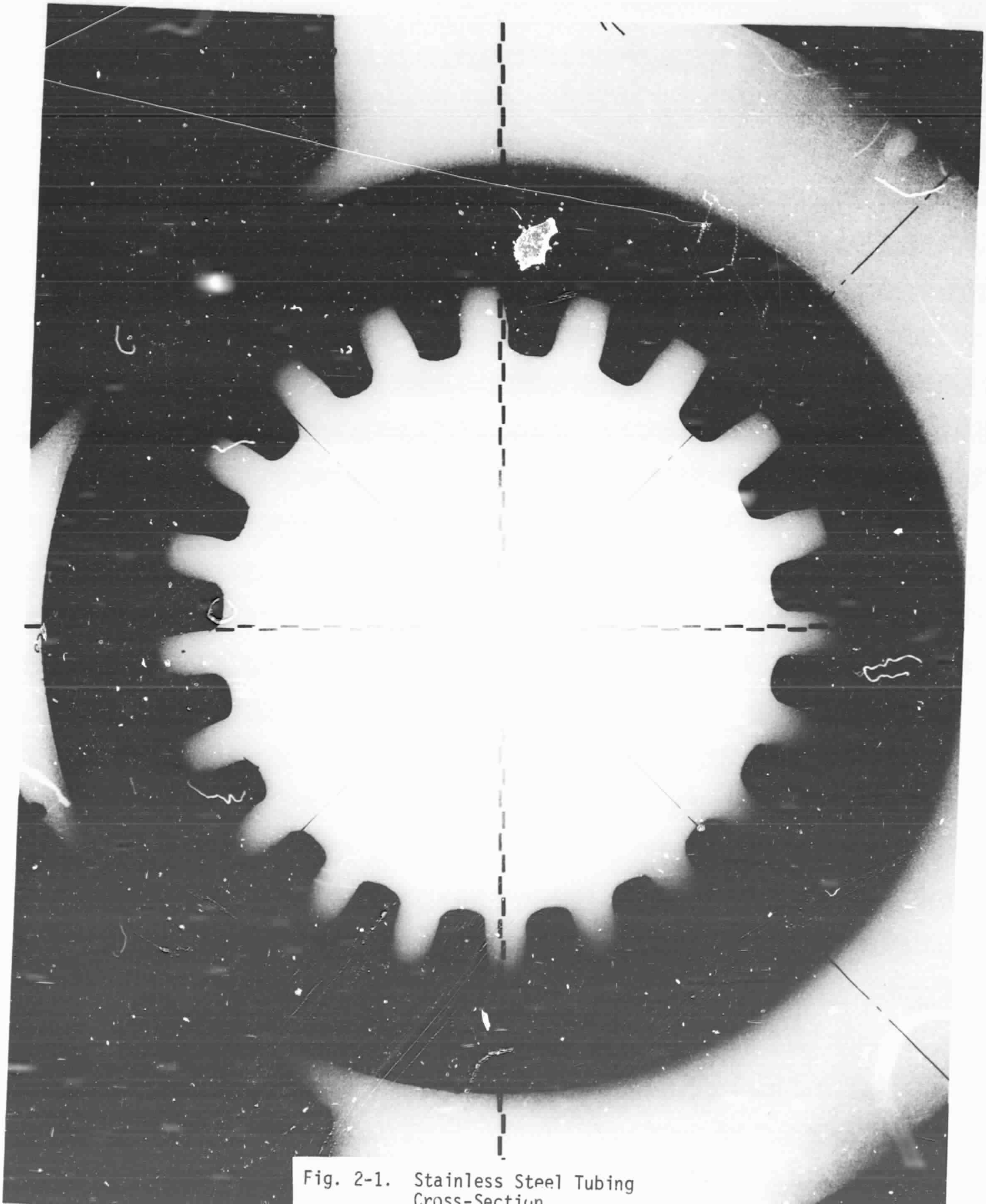

Fig. 2-1. Stainless Steel Tubing Cross-Section

TABLE 2-1

CHARACTERISTICS OF AXIALLY GROOVED TUBING

	mm	in.
No. of grooves	20	
Groove width	0.607	.024
Groove depth	0.922	.036
Fin thickness	0.584	.023
Fin corner radius	0.2	.008
Groove aspect ratio	1.52	
Outside diameter	12.52	.493
Inside diameter	7.58	.298
Root diameter	9.43	.371

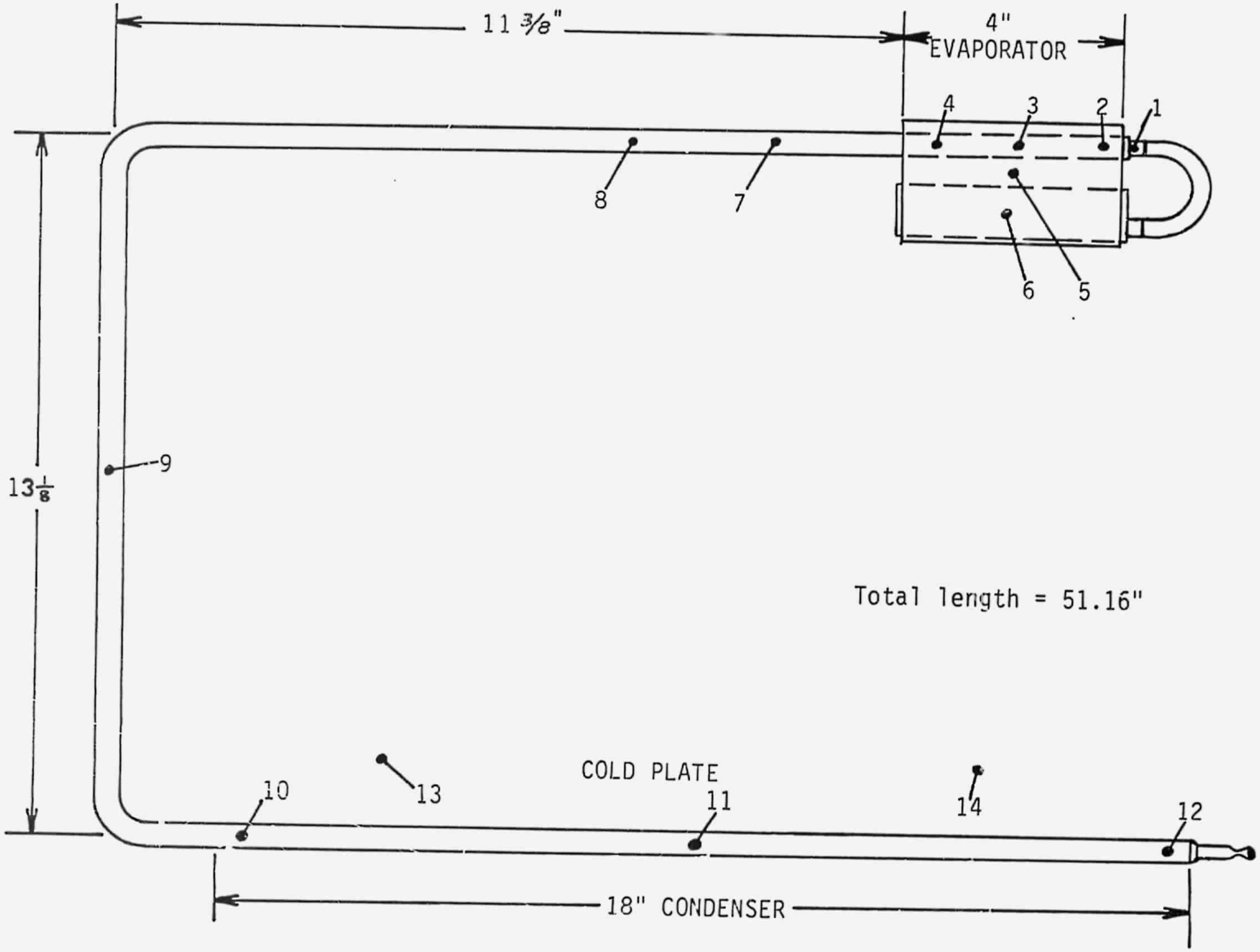

Fig. 2-2. Liquid Trap Diode Heat Pipe Irstrumentation Schematic

interaction between the axial grooves and the liquid trap. A 0.3 kg aluminum block is coupled to the evaporator and reservoir. This mass is used to absorb the shutdown energy and reverse heat flow.

3.0 THERMAL TESTS

3.1 Test Set-Up

The test set-up for the ethane charged heat pipe is defined in drawing BK042-1003, "Test Set-Up of Diode Heat Pipe BK042-1000 in B & K Vacuum Chamber." The instrumentation for this test is indicated in Fig. 2-2. Heaters were attached to the evaporator block for forward mode operation and to the cold plate to regulate the sink temperature and to provide a heat source for reverse mode operation. Cooling was provided by a liquid nitrogen (LN) reservoir which was thermally coupled to the cold plate. The entire set-up was insulated with multi-layer insulation blankets and installed in the vacuum chamber. All tests were conducted in accordance with BK042-1001 (Ref. 2)

3.2 Test Results

Transport tests were conducted at 150, 165, 180, 200 and 220°K with the heat pipe at an adverse elevation of 0.224 cm (0.089 in.). These results are compared with predicted values in Fig. 3-1. The theoretical values include the effect of condenser back-pumping which had been neglected in the original analysis (cf. Ref. 1). This accounts for a 16% reduction in transport capability. The measured values are 2-3 watts below predicted at 180°K and higher. Part of the difference is due to parasitic inputs which are approximately 1.5-2 watts.

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2. BK042-1001, "Test Procedure for Cryogenic Axially Grooved Thermal Control Heat Pipes," B & K Engineering, Inc., October, 1977.

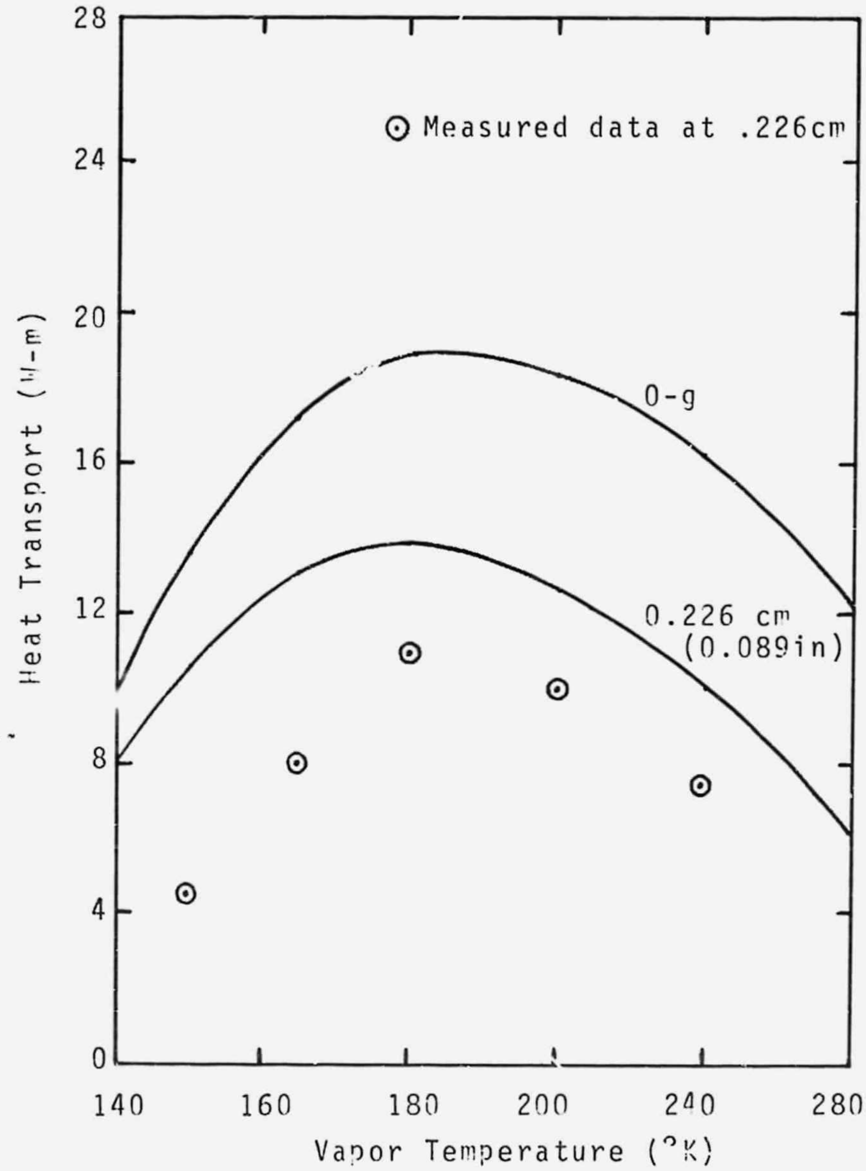

Fig. 3-1. HEPP diode heat pipe prototype performance

In addition some discrepancy could be due to irregularities in the groove form. The larger differences at the lower temperatures are due to increased parasitics and to undercharged conditions.

Transport versus elevation data are shown in Fig. 3-2. Also, shown is the original data. Again, the measured data is lower than the predicted with parasitic heat losses accounting for most of the difference. As indicated in this Fig. the 11 watt heat load obtained at an elevation of 0.23 cm and 180°K is virtually identical to the test result obtained 27 months before. While the original test data is limited, there has been no apparent degradation in the transport capability of this heat pipe.

Reverse mode behavior is shown in Figs. 3-3 and 3-4 for the January '78 and current tests. The reverse mode test consisted of applying a large heat load to the forward mode condenser section. The heat pipe's axial temperature profile was then monitored to observe successive "dry-out" along its length as fluid was entrapped in the diode reservoir. The behavior is essentially identical for both tests. In each case, the condenser was completely "dried-out" after 12 minutes. During this period of time, the evaporator absorbed 1.11 W-hr. of energy, exclusive of parasitics. This corresponds to 85% of the latent heat of the ethane fluid inventory. In the current test the shut-down through TC9 occurs in 45 minutes versus 65 minutes in the original test. The shorter time could be due to slightly higher parasitics. In any case, the reverse mode behavior is at least as good as originally observed.

In summary, the forward and reverse mode behavior of the HEPP diode heat pipe prototype is virtually unchanged after a shelf life of 27 months.

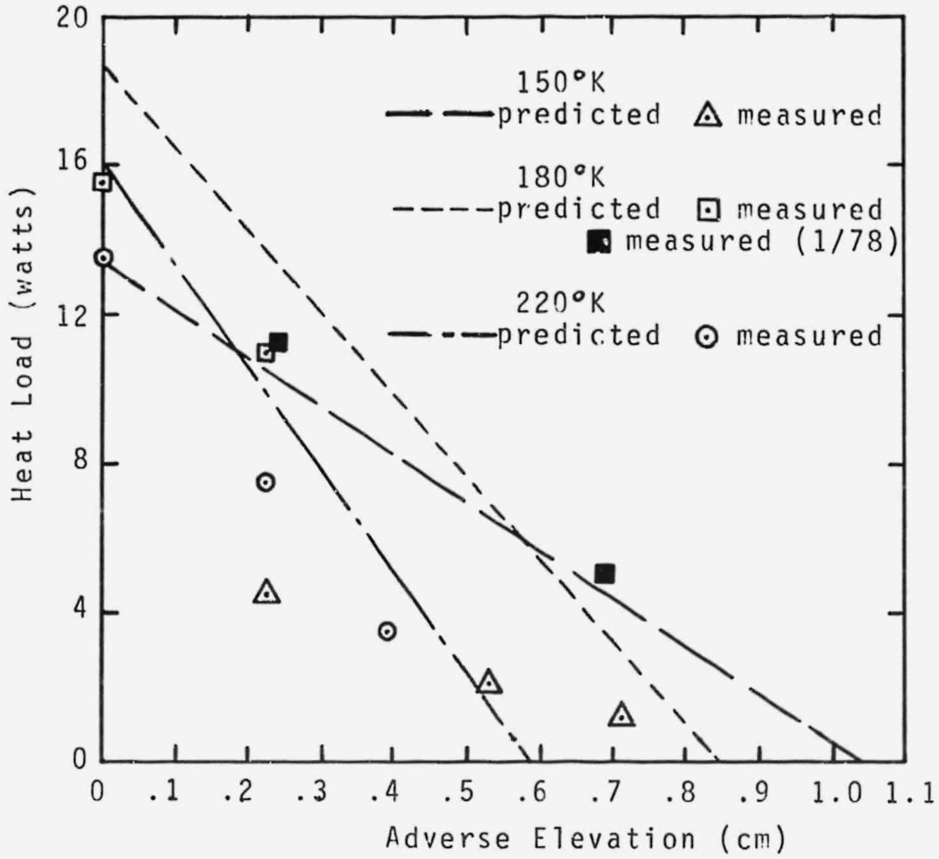

Fig. 3-2. Transport vs. elevation for HEPP diode prototype heat pipe

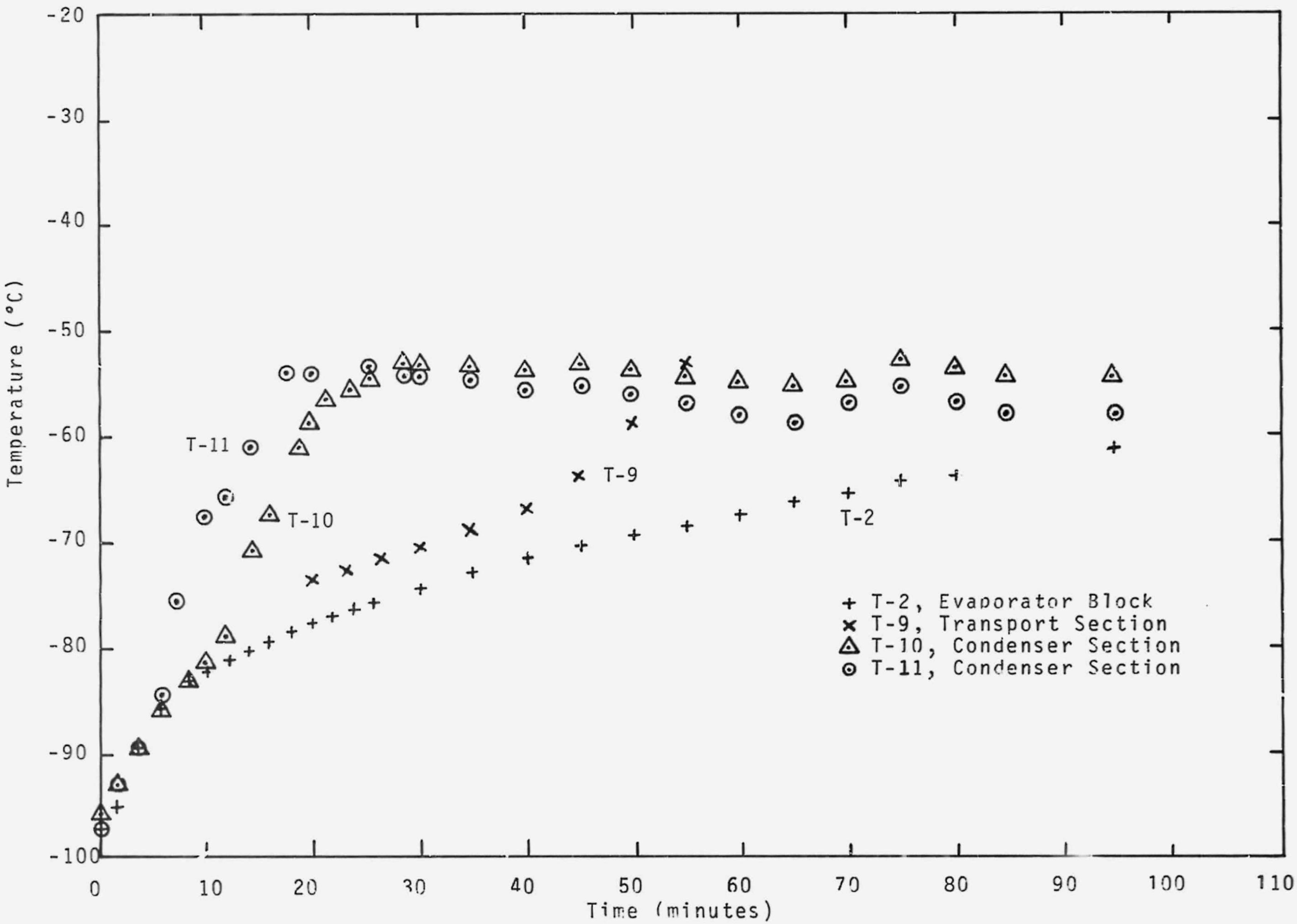

Fig. 3-4. Reverse mode behavior of HEPP diode heat pipe prototype (4/80)

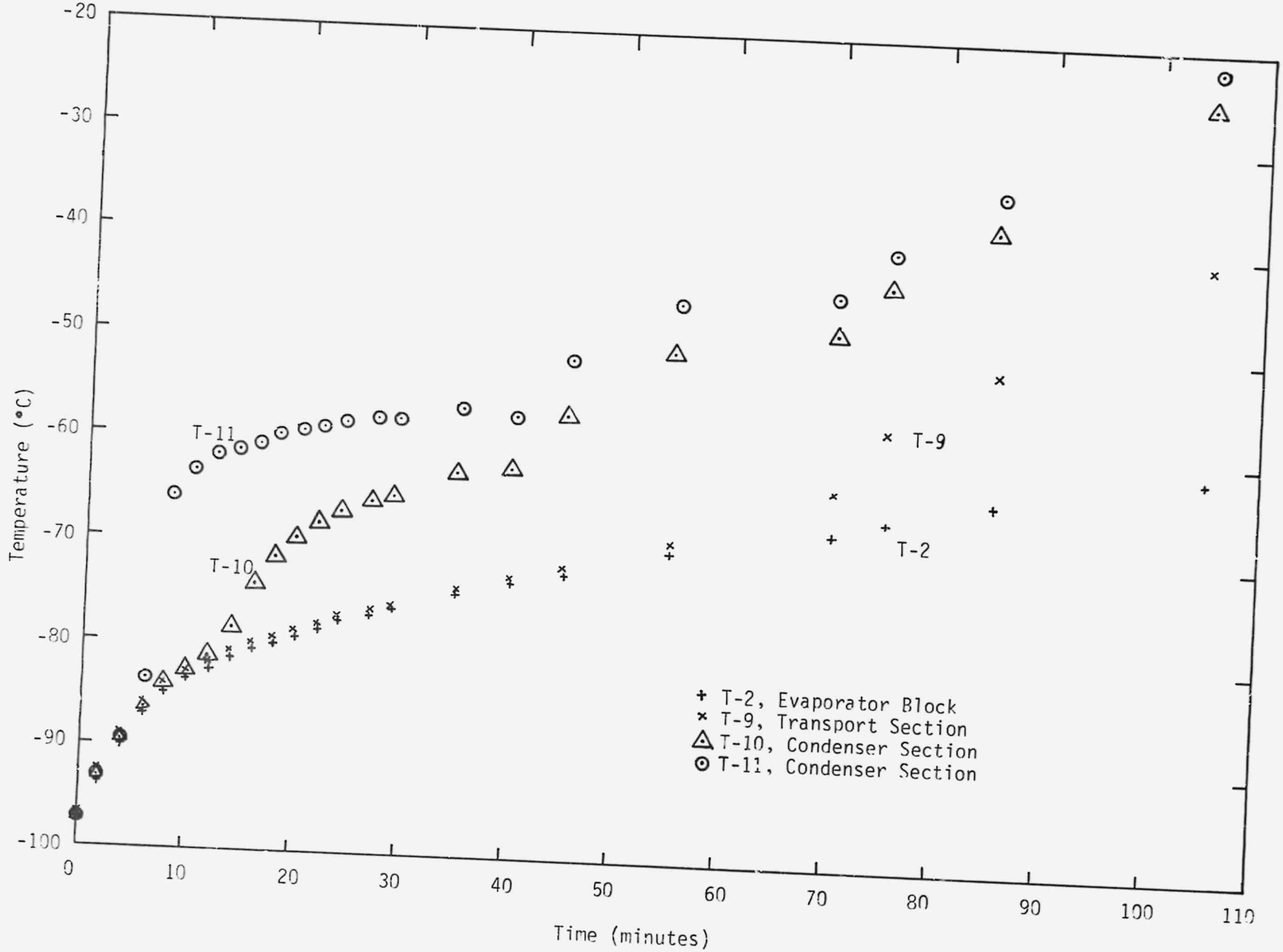

Fig. 3-3. Reverse mode behavior of HEPP diode heat pipe prototype (1/78)